A Detector setup for Heavy Ion Computed Tomography *

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Radiotherapy with ion beams is a method which allows the precise dose delivery to the tumor sparing the surrounding healthy tissue, thanks to the steep increase of the dose deposition at the end of the beam path (Bragg peak). The development of innovative imaging techniques is quite important for the precise treatment, improving the accuracy of the calculated ion ranges in tissue and avoiding range uncertainties.

A dedicated detector for range monitoring prior to or in-between treatment based on a stack of ionization chambers is being developed in GSI. The detector is designed to detect the depth of the Bragg peak of the ion beam penetrating the target. It consists of a stack of large-area parallel-plate ion chambers and passive or active absorbers (see Fig. 1(a)). A prototype based on the combination of 61 ICs (6mm gas gap, and 25μm thick aluminized Kapton foils for the signal electrodes) and absorber plates consisting of 3 mm thick slabs of PMMA has been developed at GSI. It was applied for the feasibility studies of the HICT method with ion beams at the Heidelberg Ion Therapy center (HIT)[1]. In order to achieve a higher resolution a new detector is currently set up at. Since the thickness of the absorbers gives the nominal resolution of the measured range, the new system with 1mm thick absorbers will have a 3 times higher granular structure than the prototype. A schematic drawing is shown in Fig. 1(b).

Along with the design, the response of the new detector has been simulated using GEANT4[2] and Garfield++[3]. The Bragg peak for a ^{12}C beam injected into the 128 parallel-plate ionization chambers interleaved with 1 mm PMMA absorbers has been simulated. The energy and angular straggling of the heavy-ion beam in the each absorber was calculated by GEANT4. The primary electrons from the beam and their drift tracks and induced currents in the ICs were calculated by Garfield++. The effect of the light fragments from the beam produced in the absorbers on the spectrum of Bragg peak is also studied. In Fig. 2 the simulated spectra for a 200 MeV/u ^{12}C beam and light fragments produced in the material traversed are shown. The production cross sections of light fragments are based on EPAX2[4]. In Fig. 2, a clear Bragg peak of ^{12}C can be seen. Aside from the assembly of a full scale detector system with 128 ICs further theoretical studies are in process.

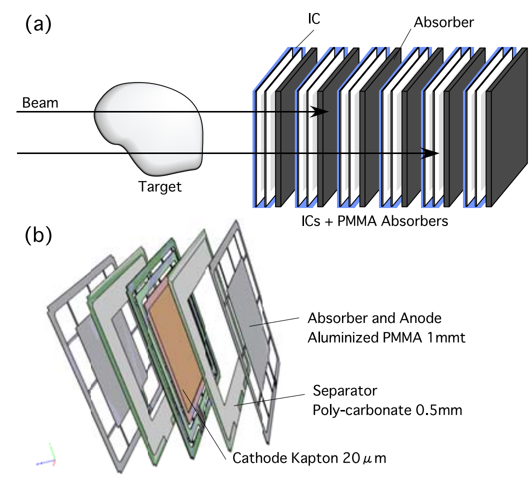

Figure 1: A schematic drawing of the principle of the range monitoring detector for cancer treatment (a), and designs of electrodes and absorbers for the detector (b).

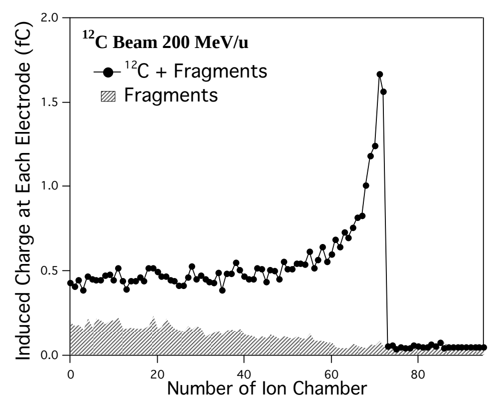

Figure 2: Spectra of ^{12}C beam and light fragments produced within the new detector, simulated using Garfield++ and GEANT4.

References

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